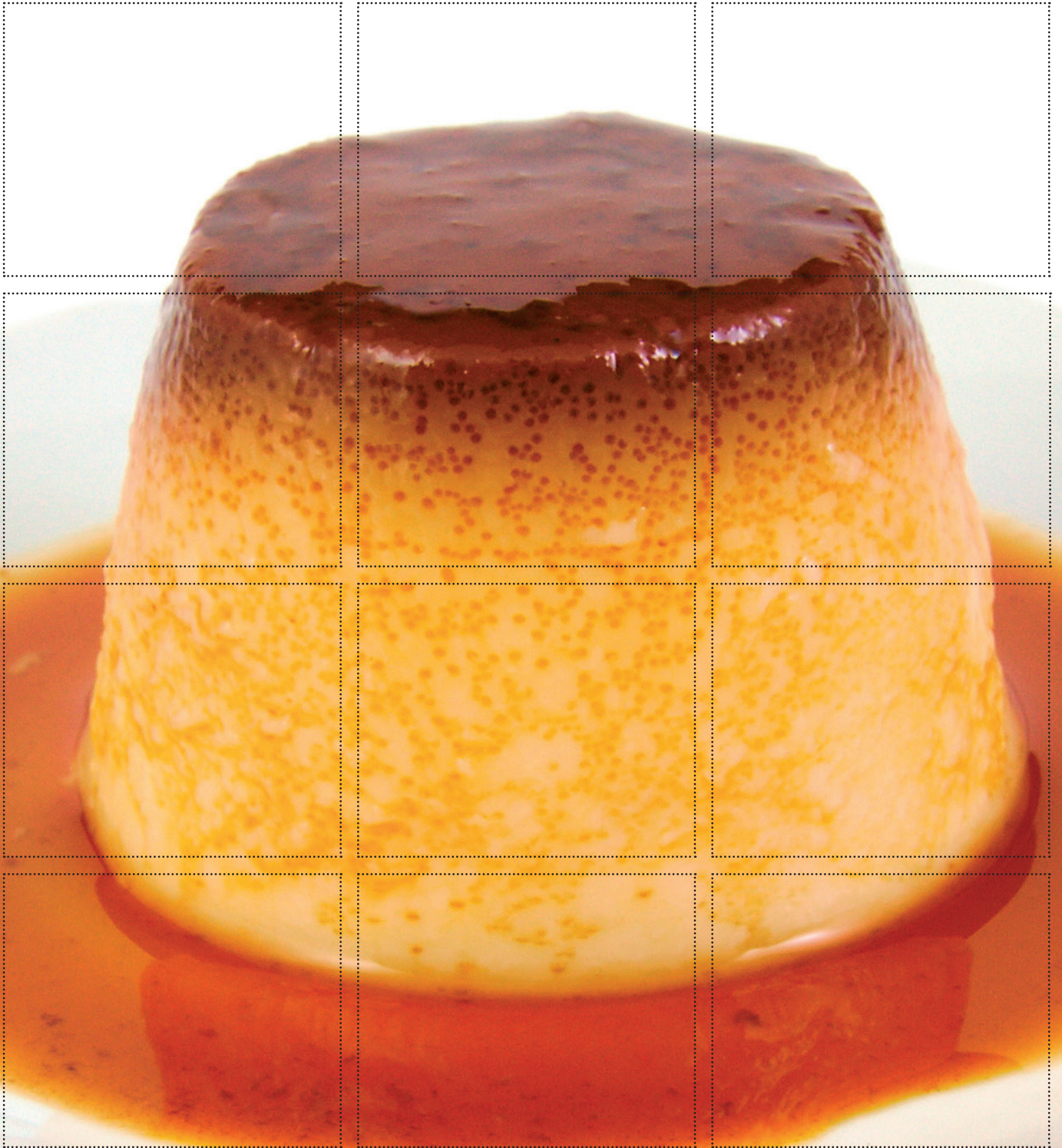


INQUIRY AND ASSESSMENT UNIT



PROOF OF THE PUDDING

Optimising the perfect pudding – an investigation good enough to eat!

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PROOF OF THE PUDDING

OPTIMISING THE PERFECT PUDDING – AN INVESTIGATION GOOD ENOUGH TO EAT!

Overview

KEY CONTENT/CONCEPTS

- Groups of nutrients
- Colloidal systems
- Health nutrition
- Attitudes towards healthy nutrition and lifestyle

LEVEL

- Lower second level
- Upper second level

INQUIRY SKILLS ASSESSED

- Planning investigations
- Developing hypotheses
- Forming coherent arguments
- Working collaboratively

ASSESSMENT OF SCIENTIFIC REASONING AND SCIENTIFIC LITERACY

- Scientific reasoning (proportional reasoning; argumentation; observation; making comparisons; drawing conclusions; identifying variables; transfer of knowledge from model to real system)
- Scientific literacy (understanding the scientific concepts under investigation)

ASSESSMENT METHODS

- Classroom dialogue
- Teacher observation
- Peer-assessment
- Self-assessment
- Worksheets
- Student devised materials (pudding, final report)
- Presentations
- Other assessment items (homework exercise)

Classroom materials for this Inquiry and Assessment Unit are available at WWW.SAILS-PROJECT.EU



1. INQUIRY AND ASSESSMENT UNIT OUTLINE – PROOF OF THE PUDDING

The **Proof of the Pudding** SAILS inquiry and assessment unit outlines an inquiry activity in which the students (plan to) prepare a “good” pudding. This can focus on biological aspects – nutrition, energy content of foods, quality of nutrients, healthy lifestyles – and chemical concepts – groups of organic compounds, colloid systems, and sol gels. The close connection with everyday life and learning based on hands-on activities raise the students’ interest. The three activities first introduce the topic, develop into planning and implementing an investigation and end with reflection on new knowledge. These activities can be implemented in two lessons (~90 minutes), but preparation of the pudding takes more time and may be assigned as homework.

Through this activity, students develop their inquiry skills in *planning investigations* by distinguishing alternatives and constructing models, as well as skills in *developing hypotheses, forming coherent arguments* – setting variables, handling quantities, making comparisons, making judgements and decisions, analysing and critiquing experiments – and *working collaboratively*. The assessment opportunities described include student observation, group discussion or presentation and evaluation of student artefacts.

The unit was trialled by teachers in Ireland, Slovakia, Greece and Hungary, with students aged 14-18 years, in five classes in total. The teaching approach in the case studies was generally that of *guided inquiry* (*open inquiry* for one Hungarian class). The assessment of *planning investigations* was carried out in all case studies. In Ireland, Slovakia and Greece, the assessment of *forming coherent arguments* and *working collaboratively* is also described.



2. IMPLEMENTING THE INQUIRY AND ASSESSMENT UNIT

2.1 Activities for inquiry teaching & learning and their rationale

The **Proof of the Pudding** SAILS inquiry and assessment unit was developed as part of the FP7 PRIMAS project¹, and adapted for use in the SAILS project by the team at the University of Szeged. In this unit, students are tasked with the preparation of a “good” pudding. The unit comprises three activities; in the first activity the theoretical concepts underlying the activity are introduced, in the second activity students plan an experiment to test their hypotheses of what makes a good pudding and, finally, the students reflect on what has been learned through the activities.

The depth of prior knowledge for implementing the unit depends on the focus of development. For lower second level, the goal for development can be developing research skills. For upper second level students, an inquiry into the colloid state and systems based on knowledge in the field of chemistry and physics, or considering nutrients and the healthy diet is appropriate. It is not a problem if the group does not have prior knowledge of the topic, as searching for information can be a part of the task. However, in all cases, it is important that the students are able to anchor and link the newly acquired information to their existing knowledge and increase their understanding.

Activity A: Preparation of inquiry

Concept focus	Introduction of background theory Features of carbohydrates, proteins, fats and minerals Nutrition
Inquiry skill focus	Developing hypotheses Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (identifying problems, making reasoned decisions) Scientific literacy (explaining scientific concepts)
Assessment methods	Classroom dialogue

Rationale

This activity introduces the concept of the inquiry – preparation of a good pudding – and allows the students to review their prior knowledge and consider the problem for investigation. This warm-up activity raises students’ interest and enthusiasm about the task, while also providing a theoretical introduction. This ensures that the students can identify appropriate content

knowledge and enables the teacher to introduce complementary conceptual knowledge connected to the task, which is necessary to solve the problem.

Suggested lesson sequence

1. Students divide into groups of 3-4 (can be self-selected or teacher assigned)
2. As a warm-up activity, the teacher offers some supportive questions, such as
 - a. What aspects could you use to compare an industrial pudding with a homemade one?
 - b. What makes a pudding “good” or “bad”? What positive features or quality problems can you define?
 - c. Which pudding can be made more easily?
3. Once these questions have been discussed, the teacher can ask further questions to build on the conceptual knowledge connected to the task, such as:
 - a. What kind of basic nutrient groups do you know?
 - b. What are the advantages and disadvantages of those nutrient groups?
 - c. From which food groups/categories would you choose the main nutrients for a “good” pudding?
4. The teacher then chairs a whole-class discussion to define the problem (how is a good pudding made) and to focus the aim of the inquiry (jelly state or nutrition)

Activity B: Planning investigations & carrying out the inquiry

Concept focus	Model system for the jelly state Planning preparation of a “good” pudding
Inquiry skill focus	Developing hypotheses Planning investigations Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (making reasoned decisions) Scientific literacy (explain colloid state and sol/gel transformation)
Assessment methods	Classroom dialogue Worksheets Student devised materials

¹ Promoting inquiry in mathematics and science education across Europe (PRIMAS), <http://www.primas-project.eu> [accessed October 2015]; PRIMAS guide of supporting actions for teachers in promoting inquiry-based learning, <http://www.primas-project.eu/servlet/supportBinaryFiles?referenceld=2&supportld=1301> [accessed October 2015]

Rationale

In this activity, students plan their investigations, considering both the model system and ingredients for a real pudding.

a) Planning a model system – setting the jelly state

- Simplification of the end product, construction of a model system that enables the formulation of the desired state
- Compiling the experimental model system, carrying out the investigation
- Collecting data using the model, defining the appropriate dilution rate.

This part of the activity encourages comparison and analogical thinking and gets the students to make judgements and decisions. They work towards developing a hypothesis and plan their investigation of the model system (construct models, distinguish alternatives, setting variables). This is an opportunity to work collaboratively and share knowledge.

b) Preparing the end product – planning the ingredients of a real 500 g pudding

In the latter half of this activity, the students further develop their hypotheses and planning. They should look for connections, distinguish between alternatives and make decisions based on the evidence obtained in part a):

- The choice of further ingredients of the planned jelly on the basis of the model system
- Formulating quality aspects and planning the content accordingly
- Preparing the final product

This part of the activity encourages analytical thinking, ranking on the basis of quality aspects, looking for connections, distinguishing alternatives and use of systematic thinking, considering the effect of ingredients and connections between quantity and quality.

Suggested lesson sequence

1. Students divide into groups of 3-4 (can be self-selected or teacher assigned)
2. The teacher asks the students to “Plan an experiment to model the jelly state of a pudding,” in which they address each of the following aspects:
 - a. Clearly formulate hypotheses related to your question.
 - b. Present arguments that support your hypothesis, based on correct and relevant scientific knowledge.
 - c. Plan an investigation that allows you to analyse your hypotheses.
 - d. Describe in detail all the steps, including the variables you want to study, variables you have to control and all the equipment and materials necessary to its realisation.
3. The teacher may ask some prompt questions while the groups plan their investigations:
 - a. Do you know materials of similar states?
 - b. How would you define when the pudding is in an appropriate state?

- c. Which compounds could lead to the condensed state of the solution?
 - d. What aspects and methods could you find in order to define the differences between the condenser materials?
 - e. What is the simplest model you could use for the jelly state of the pudding?
 - f. How could you find out the ratio of compounds for the model system?
4. Students discuss their investigation plans with the teacher and if necessary reformulate it, before carrying out their investigation of the model system
 5. The teacher now asks the students to consider a real pudding
 - a. Define the quality aspects of the end product
 - b. Qualify and choose further components
 - c. Plan the final content
 - d. Prepare the final product, if feasible

Activity C: Evaluation and feedback

Concept focus	Reflection on acquired knowledge
Inquiry skill focus	Forming coherent arguments
Scientific reasoning and literacy	Scientific reasoning (drawing conclusions) Scientific literacy (presenting scientific data)
Assessment methods	Classroom dialogue Worksheets Student devised materials

Rationale

In the final part of the unit, each student reflects on what they have learned in carrying out the activity. This is an opportunity to form conclusions, present their final product and argue its merits, thus consolidating their content knowledge. They should exhibit critical thinking, coherent argumentation and reflective thinking.

Suggested lesson sequence

1. Student groups present their results from Activity B: Planning investigations & carrying out the inquiry to the class
2. The teacher chairs a whole-class discussion, considering the results as a whole. The teacher can ask some prompt questions:
 - a. What criteria did you use to evaluate the end product?
 - b. On what basis can you argue for your product?
 - c. What critical arguments could you formulate against other products?
 - d. How can you evaluate your own and the groups' work? What were your strengths and weaknesses?

2.2 Assessment of activities for inquiry teaching & learning

When dealing with the unit activities, it is important that the assessment is in line with the objectives of the topic and with the curriculum. It is also important that students know before they commence their work how to report their results and how they will be judged. The skill of *planning investigations* is a key inquiry skill for development during the implementation of this inquiry and assessment unit, but opportunities for the assessment of other skills and competencies have been identified for each of the unit activities. The students can be assessed, either as groups or as individuals, through the use of discussion and provision of oral formative feedback during the lesson. During assessment, the teachers can consider student's concept knowledge, inquiry skills and *scientific literacy*. In addition, self- and peer-assessment may be carried out. For each of the activities, some suggested skills for assessment and criteria for success are outlined.

Assessment of skills in Activity A: Preparation of inquiry

Concept knowledge

- Can the students identify the most important features of carbohydrates, proteins, fats, minerals and vitamins?
- Do the students understand the importance of these compounds in the physiology of nutrition

Inquiry skills – planning investigations, forming coherent arguments

- Are students able to distinguish the different ingredients of products?
- Are they able to formulate the main features of the jelly states?
- Are they able to argue their opinions appropriately?

Scientific reasoning and scientific literacy

- Can students distinguish between closed and open thinking?
- Do they display evidence-based reasoning?
- Can they engage in critical thinking (e.g. in connection with media advertisements)?
- Do they demonstrate consumer awareness?

Assessment of skills in Activity B: Planning investigations & carrying out the inquiry

Concept knowledge

- Can the students identify the physical features of the jelly states and the conditions of its formulation?
- Do the students know the chemical structure, origin and solubility of flour, starch and gelatine in water?
- Do students understand the colloid state/system, sol/gel transformation?

Planning investigations

- Are the students able to recognise and justify the role and importance of the model system?
- Are they able to plan a suitable order of dilution?
- Are they able to appropriately observe the results (physical states and changes in the model systems)?

Scientific reasoning and scientific literacy

- Drawing conclusions on the basis of the model system and applying them to the end product
- Distinguishing variables (content, temperature)

Assessment of skills in Activity C: Evaluation and feedback

Forming coherent arguments, scientific reasoning, scientific literacy

- Do students engage in critical thinking while debating with peers?
- Can the students present a coherent argument when assessing their own and others' work?
- Do the students engage in reflective thinking?

2.3 Further developments/extensions

The suggested two lesson periods allocated to cover the unit (approximately 90 minutes) are not sufficient to exploit all the possibilities inherent in the task. Students can manage to finish the preparation of the designed end product with sufficient support, but designing them along multiple design aspects and critical analysis of each other's end products requires more time. Thus, it is suggested that one more period be attached to the unit where possible. This time could be allocated to more detailed analysis (e.g. energy content, composition of nutrients) or a more thorough development of research skills, as well as observation, support and assessment.

3. SYNTHESIS OF CASE STUDIES

The **Proof of the Pudding** SAILS inquiry and assessment unit was trialled in four countries, producing four case studies of its implementation – **CS1 Ireland**, **CS2 Slovakia**, **CS3 Greece** and **CS4 Hungary**. All the case studies were implemented by teachers who had some experience of teaching through inquiry, but the students involved had generally not been taught through inquiry, except in **CS3 Greece**.

The ages of the students involved in the case studies were 15-16 years old in **CS1 Ireland**, **CS2 Slovakia** and **CS3 Greece**, while in **CS4 Hungary** the unit was trialled with two classes – one science class of 14-15 year olds and one biology class of 17-18 year olds (Table 1). In all case studies the students were of mixed ability; **CS1 Ireland** was the only case study with a single-sex class (all female).

The case studies focus on developing students’ skills in *planning investigations*, *forming coherent arguments* and *working collaboratively*. *Scientific reasoning* capabilities and *scientific literacy* were also assessed, in particular evaluating skill in forming arguments and transferring knowledge from the model to the real system. A wealth of assessment methods are detailed, in particular classroom dialogue, evaluation of student devised materials – the pudding – and peer- or self-assessment.

3.1 Teaching approach

Implementation

The case studies show that, taking the main problem raised by the unit and the teaching recommendations into consideration, the range of applications can be expanded, which is partly due to the multidisciplinary nature of the content. This way, emphasis can be put on either the chemistry or biology parts. The main focus was on biological aspects in **CS3 Greece** and chemical aspects in **CS4 Hungary**. The analysis of the problem can be separated into construction of a model and the actual adaptation of the model. Dealing with the first part of the problem develops theoretical and proportional thinking mostly, whereas the second part helps in practical adaptation and encourages combinative and critical thinking. The latter can

be used more effectively with groups of students at a higher age. Each case study places a strong emphasis on eliciting students’ preliminary knowledge and focuses them on the task, strengthening their motivation as well as their independent research skills in the process. Each trial was based on group work (or pair work in case of **CS2 Slovakia**), but these were complemented with homework assignments (**CS1 Ireland**) and individual research opportunities as well.

In **CS1 Ireland**, states of matter, gelatine structure and the nature of science were addressed. The teacher introduced the inquiry task question: “What makes a good pudding?” In the planning phase of the investigation the students were guided by a worksheet. Tasks included class and group discussion, ranking and choosing variables, making predictions, and listing required materials and tools. The teacher assigned homework to investigate gelatine and to complete an individual plan for the investigations. In the phase of carrying out the inquiry, the students discussed their homework and they were given a more detailed recipe and noted what variable they were evaluating. They then revised their plan, implemented it and recorded notes during the experiment on their worksheets. The investigated variables were: gelatine type and concentration, liquid type (milk, soya milk, water, and various fruit juices) and temperature of liquid. During the evaluation and feedback phase, students completed presentations and answered teacher questions on their work, listened and took notes and judgements on other groups presentations.

In **CS2 Slovakia**, the teacher carried out a 15-minute discussion with the students on the previous biology lesson, to prepare them for their research. Students answered questions and after the discussion they formed pairs or groups of three members. With the teacher, they agreed on two tasks: (1) to plan and carry out an experiment to test the ratio of liquid and thickeners, and (2) to propose a homemade recipe for 500 g of the pudding. Students were asked to bring ingredients (starch, flour, gelatine or agar of their own choice) for the next lesson, cook their pudding at school and defend its composition in terms of nutritional value.

Table 1: Summary of case studies

Case Study	Activities implemented	Duration	Group composition
CS1 Ireland	Activities A-C	Three lessons (80 min each)	<ul style="list-style-type: none"> Groups of 3 students
CS2 Slovakia	Activities A-C	One double lesson (90 min)	<ul style="list-style-type: none"> Groups of 2-3 students Single-sex groups
CS3 Greece	Activities A-C	Two lessons (1x90 min and 1x45 min)	<ul style="list-style-type: none"> Groups of 3-4 students Self-selected, mixed gender
CS4 Hungary	Activities A-C	Two lessons (45 min each)	<ul style="list-style-type: none"> Trialled in two classes Mixed gender, mixed ability

In **CS3 Greece**, the focus of the implementation was centred on biological aspects, in particular the topics of nutrients and healthy diets. The teacher prepared several worksheets to guide the inquiry and aid in assessment. The students started the lesson with a discussion of the inquiry question posed: “How can we make a really good cheesecake?” As a result, further research questions arose. The teacher observed them while at the same time setting more questions to guide them. The students described several viewpoints of the meaning of “good,” most of them relating to a healthy diet. The students described the main quality criteria of the industrial cheesecake as: cost, ease of manufacture, good taste, and appearance. Students were asked to analyse a given cheesecake recipe from different nutritional perspectives. The teacher gave the students two internet links in order to help students with their calculations and also explained to students how to use these tools. The students had to formulate hypotheses on how they could revise the original pudding recipe in order to increase nutritional value and decrease the energy content of the end product. Students were asked to draw two bar graphs to represent total content of nutrients – one for the original recipe and one for their suggested recipe. The teacher then explained to students the steps required to prepare a pudding and gave them feedback on their questions. During the final lesson, the teacher asked students to present and discuss their experience along with their findings to the class.

The **CS4 Hungary** implementation focused on groups of nutrients, colloidal systems, and healthy nutrition. In terms of IBSE skills, this case study focused on *planning investigations* (including constructing the model system), *developing hypotheses* and *scientific reasoning* (through searching for information, and several types of debating and thinking skills – comparing, classification, connecting, and analogical thinking). During the preparatory phase the students’ prior knowledge was determined and any deficiencies addressed. In this phase, teacher presentation dominated; the students answered the teacher’s questions and tuned in to the task, their interest increased and their conceptual

knowledge was stimulated. In the second phase the students had to construct a model system to plan the jelly state of the pudding. They had to understand that before doing the real processes on a large scale it is practical to first test it using a model system to identify what works and how. In the third phase the groups presented their prior ideas and compared them with the features of the end product. Through evaluating each other’s work they gave critical comments.

Adaptations

The unit description is more of a framework than a set script. By interpreting the problem under inquiry and the learning goals correctly, there are many ways and possibilities to adapt it to the local requirements. The case studies describe adaptations and their rationale, which are typically connected to time required for the inquiry (**CS2 Slovakia**), the way it fits into the curriculum (**CS2 Slovakia** and **CS3 Greece**) and the lack of students’ research experience (**CS1 Ireland**). During adaptation, teachers prepared different supporting materials, such as student worksheets (**CS1 Ireland** and **CS3 Greece**) and introductory supporting materials (**CS4 Hungary**). The teachers selected the skills to be assessed based on the specific group’s needs and developmental goals. They identified aspects for assessment and determined skill levels that were correlated with the student activities and could be observed during specific tasks. Specific adaptations were:

- In **CS1 Ireland**, the adaptations were decided upon based on the short time available and students’ limited previous experience of inquiry and science. The teacher followed the general sequence outlined in the unit, but prepared worksheets to aid the lesson to run smoothly.
- In **CS2 Slovakia**, adaptation of the unit was necessary for two consecutive hours (biology and chemistry). It took place in a divided class (16 students) during two lessons (90 minutes). It was also necessary to tailor the topic to fit into the thematic units that are currently taught in biology and chemistry.

Table 2: Inquiry skills identified by teachers in the case studies

CS1 Ireland	<ul style="list-style-type: none"> • Planning investigations • Forming coherent arguments • Working collaboratively • Scientific reasoning (proportional reasoning)
CS2 Slovakia	<ul style="list-style-type: none"> • Planning investigations • Forming coherent arguments • Working collaboratively • Scientific reasoning (argumentation)
CS3 Greece	<ul style="list-style-type: none"> • Developing hypotheses • Planning investigations • Forming coherent arguments • Working collaboratively
CS4 Hungary	<ul style="list-style-type: none"> • Planning investigations • Scientific reasoning (drawing conclusions, identification of variables, transfer of knowledge from model to real system)

- In **CS3 Greece**, the teacher made adaptations to the suggested activities in order to fit with the State Curriculum and the background of the students at this level. The teacher assembled and provided five worksheets, which gave the students support to start working individually. The teacher could assess the achievements and the skill level based on the answers to the questions on the worksheets. In this trial, emphasis was put on the second part of the unit's task so the students dealt more with biology rather than chemistry topics.
- In **CS4 Hungary**, the plan of the unit was compiled on the basis of non-structured or half-structured problems. The teachers sought to find a topic that was interesting for students and encouraged them to engage in individual research.

Inquiry skills addressed

As outlined in the assessment of activities for inquiry teaching and learning section of the unit, the proposed activities could be used to assess a range of inquiry skills, such as *planning*

investigations, developing hypotheses, forming coherent arguments and working collaboratively, as well as increasing *scientific reasoning* capabilities and *scientific literacy*. However, within the case studies, the teachers selected different inquiry skills for the assessment, as shown in Table 2.

3.2 Assessment strategies

No assessment tools are provided in the assessment of inquiry teaching and learning section of this unit, and each of the case studies developed their own strategies for evaluation of inquiry skills. In both **CS1 Ireland** and **CS3 Greece**, the teachers used rubrics to assess all of the inquiry skills and *scientific reasoning* and *literacy*. **CS2 Slovakia** and **CS4 Hungary** focused on specific inquiry skills and primarily utilised formative assessment through oral feedback during the lesson. Most case studies included some aspect of peer- or self-assessment, allowing students to engage in and understand the evaluation process.

In **CS1 Ireland**, the assessed skills were *planning investigations, developing hypotheses, working collaboratively, forming coherent*

Table 3: Rubric for planning investigations

Characteristic	I	II	III	IV	Least preferred
Initial idea					Nebulous non-focused
Making judgements or decisions					Indecisive
Developing hypotheses					No cause and effect identified
Working collaboratively					Working in isolation
Ranking					Indecisive
Refining					No refinement

Table 4: Student rubric from CS1 Ireland

Assessed Skill	Emerging	Developing	Consolidating	Extending
Planning an investigation	Goes for an initial idea.	Looks at different options and decides on one, but without careful consideration regarding relevance or testability.	Looks at many different options and ranks them on scientific relevance and testability. Justifies decision through critique or by scientific explanation.	Considers the evidence from trials and others' results or ideas. Refines their plan using results from experiments.
Carrying out an investigation	In need of continuous support and instruction. Using equipment unsafely or inappropriately.	Occasional support needed. Demonstrates the ability to use equipment safely and appropriately.	Able to run experiments confidently and relatively independently, in a well organised and time efficient manner.	Demonstrates the ability to continually run experiments independently and safely without need of assistance.
Recording and analysing results	Limited recording of results, or none.	Results recorded and presented appropriately.	Recording, presenting results appropriately. Some analysis of results demonstrated.	Recording, presenting, and analysing results appropriately, using critical thinking to evaluate and draw valid conclusions.

arguments and critiquing experimental design. The skills were assessed using teacher observation, questioning and review of documentation measured against pre-developed criteria. The teacher prepared a number of rubrics based on Kelly's repertory grids, which detail the characteristics desired for each level of achievement and are assigned a score from 1 to 5 (where 5 is the lowest). An example is shown in Table 3, used in the assessment of *planning investigations*, where the Roman numerals refer to the group number.

In **CS1 Ireland**, the teacher provided a student rubric (Table 4), which was displayed in the classroom during the lesson. This served as a brief instructional guide for the students and provided motivation. Each row was displayed at different points throughout the lesson sequence. When observing the classes the teacher circulated with a flip chart containing the appropriate rubrics and recorded a group grade. Formative assessment was used during the classroom activities (observation, questioning) and summative assessments were used when the teacher reviewed student worksheets and reports.

In **CS2 Slovakia**, the assessed skills were *planning investigations*, *working collaboratively* and *forming coherent arguments*. The teacher assessed them directly through dialogue with students, on the basis of the students' responses, how they planned the test and also on how they recorded their data. Furthermore

they assessed students' *scientific reasoning* (argumentation) during preparation of the recipe for homemade pudding. The teachers watched how the members of groups collaborated as well. During the activity, the teachers provided oral formative feedback. During peer-assessed activities, students listened to their classmates' arguments. Evaluation rubrics were not used, but teachers monitored the way of students referred to their plans and evaluated correctness of the arguments.

In **CS3 Greece**, the assessment was based on teacher observation, student artefacts and peer-assessment. The following skills were assessed in this case study: *developing hypotheses*, *planning investigations* (testing a hypothesis), *forming coherent arguments*, *working collaboratively*, *scientific reasoning* (observing, making comparisons) and *scientific literacy* (understanding the concepts under investigation). In order to assess some of these skills the teacher used rubrics (Table 5). The students answered all the worksheet questions. The teacher asked students to present their answers in class in order to discuss these issues between them and take feedback (formative assessment). In one worksheet, students had to fill in the cells of a table that contained the nutritional value of the recipe ingredients as well as their energy value. The teacher used the students' worksheets and the related rubric in order to assess the skill *developing hypotheses*.

Table 5: Rubric used for the assessment of students' skills in CS3 Greece

Assessed skill	2 Acceptable	1 Needs improvement	0 Poor/NA	Evidence from... (context of assessment)
Forming hypothesis	Yes (no gaps)	Needs improvement (some gaps exist)	No	Worksheet 2, Activity A Description: Rewrite the recipe from worksheet 1, replacing as much ingredients as you can in order to reduce fats... Justify your answer.
Testing hypothesis	Yes (no gaps)	Needs improvement (some gaps exist)	No	Worksheet 4, Step 3 Question: After all, is your recipe suitable for a tasty and well-textured cheesecake? If not could you suggest any changes for a better result?
Observing	The answer is correct (no gaps)	Needs improvement (some gaps exist)	Is irrelevant or incorrect	Worksheet 4, Step 2 Question 1: Do you believe that the ingredients used instead of these of the initial recipe, affect the final texture of the cheesecake? If yes in which way? Question 2: How does the new cheesecake taste?
Making comparisons	The answer is correct (no gaps)	Needs improvement (some gaps exist)	Is irrelevant or incorrect	Worksheet 3, Activity C, Compare Question: Compare the results of the first and second bar graph.
Understanding	The answer is correct (no gaps)	Needs improvement (some gaps exist)	Is irrelevant or incorrect	Worksheet 5 All questions

The students also carried out peer-assessment on the conclusion section of the worksheet using a rubric for *forming coherent arguments* (Table 6). The teacher discussed the criteria of the rubric with students and after that he asked them to perform the assessment. The teacher also assessed the students' observations and their final conclusions written in their worksheets. The teacher used the underlying question as evidence of how the groups managed to test their hypotheses.

Table 6: Rubric for the peer-assessment of forming coherent arguments in CS3 Greece

	1 – Poor	2 – Needs improvement	3 – Acceptable
Does the answer seem right?	No	Needs improvement (some gaps exist)	Yes (no gaps)
Do they use arguments in order to convince you?	No	Needs improvement (some gaps exist)	Yes (no gaps)
Is the argumentation being put forward complete?	No	Needs improvement (some gaps exist)	Yes (no gaps)
Does the argumentation put forward seem right?	No	Needs improvement (some gaps exist)	Yes (no gaps)

In **CS4 Hungary**, the main tool for formative assessment was the teacher's oral feedback, which was linked to student's activities. Different assessment tools were used with the different student groups. In a lower second level science class, a rubric method was utilised to represent student's achievement in two inquiry skills: *planning investigations* and *scientific reasoning* (Table 7). The assessment rubric linked directly to the lesson and could be used to help the students' further development from the existing skill level. The assessment was based on students' answers that were collected with the questionnaire.

During the preparatory phase the students' prior knowledge could be assessed. In the second phase, the group work was assessed through teacher observation and oral feedback. During the planning of the models, each group was visited by the teacher. In the third phase of the task the groups evaluated each other's work, and they expressed critical comments. Both self- and group assessment took place in this phase. In the fourth and final phase of the task, reflective thinking was evaluated; this focused on students' ability to recall and articulate their own thinking.

Table 7: Rubric used for the assessment of skills in science class in CS4 Hungary

Assessed Skill	Acceptable	Needs improvement	Poor/NA
Planning investigations	You are able to investigate a problem or to solve it and to formulate independent suggestions. On the basis of testing the suggested method you are able to revise your original ideas. You can independently recognise the variables even if they are not identified in the task. You are able to control the independent variable properly.	You can start investigating and solving the problem on the basis of given instructions but you are able to find solutions independently to emerging problems. You are not able to recognise the variables independently but on the basis of given instructions you are able to comprehend and control them.	You can hardly understand the purpose of investigating the problem but you can complete the given instructions. In the case of difficulties you need help. You are not able to recognise the variables independently, you can hardly understand them on the basis of the instruction, you often make mistakes while controlling them.
Scientific reasoning	You are able to draw conclusions on the basis of experimental results examining and measuring variables. You can transfer the results of experiment or model to real problems.	You record the results of the experiments properly but on the basis of them you are not able to draw conclusions. You can be led to the connection between the experiment, the model and real problems, but you are not able to recognise them independently.	You are not able to draw conclusions on the basis of experimental results and observations. You cannot transfer the results of experiment or model to real problems.
Experimenting	You are able to carry out the planned experiment by yourself, to recognise causality, you can write/draw the process and results of an experiment exactly.	You are able to carry out experiments with somebody's help, mostly you can recognise the causality with somebody's help, you can write/draw the process and results of an experiment with only a few mistakes.	You cannot carry out experiment by yourself at all, you cannot recognise the causalities during the experiments, you are not able to write/draw the process and results of an experiment